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SOYBEAN (*Glycine max.* (L.) Merrill) VEGETATIVE GROWTH PERFORMANCE UNDER CHEMICAL AND ORGANIC MANURES NUTRIENT MANAGEMENT SYSTEM

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ABSTRACT

Optimization of fertilizers sources and doses occupies pivotal position for triggering crops growth along with reducing a halt to environmental pollution caused by excessive use of mineral fertilizers. This field research was conducted to determine the effect of chemical and organic fertilizers on vital vegetative growth parameters including leaf area index and chlorophyll content of soybean (cv. Nova).Treatments included four different sources of fertilizers manures from sheep and cattle barns, liquid manure from cattle barn, chemical fertilizers and a control treatment was kept for comparison purpose. The chlorophyll contents of plants at different growing stages Beginning bloom (R1) and Beginning seed (R5) were measured using SPAD-502 and CM 1000 chlorophyll meter. The results indicated that physiological growth parameters including leaf area index and chlorophyll content of soybean differed significantly at stage R1 and R5 growth stages under varying fertilization regimes. The chemical fertilizers remained unmatched for recording the maximum physiological growth, while liquid manure from cattle barn performed superiorly by exhibiting the maximum leaf area index and chlorophyll content. It is recommended to use liquid manure from cattle barn for boosting physiological growth of soybean and these research findings also necessitate evaluation of different doses of liquid cattle manure to sort out the best performing dose for soybean production under changing climate.

KEYWORDS:
Leaf area index, SPAD Liquid Barn Manure, Barn Manure, Vermicompost

INTRODUCTION

Traditional intensive crop production systems requisite abundant quantities of mineral fertilizers for attaining the maximum yield as per varietal potential [1, 2]. However over time, chemical fertilizers based fertilization strategy has led to serious contamination of ground and underground water along with agro-ecosystem under changing climate [3-5]. Besides environmental concerns, alarming contamination of food and feed has once again diverted attention towards utilization of organic wasted for crop production. Legumes have been found to be the best option for crop rotation due to their ability to fix atmospheric nitrogen (N) through biological nitrogen fixation (BNF) process going on in the root nodules [6, 7]. Among legumes, soybean (*Glycine max* L. Merrill) occupies pivotal position due to genetic diversity, economic significance, oil extraction and ability to grow in varying soil and climatic conditions [8, 9]. In Turkey, soybean is being grown on 35.000 ha, with an annual production of about 150.000 tons. The per unit grain yield of soybean has remained suboptimal and inappropriate plant nutrition management constitutes one of the biggest reason which adversely effects crop growth and yield. Recently, organic manures such as sheep and cattle barn manures, compost, and other organic wastes of plants and animal origins have been reported to positively influence the growth of soybean along with restoring soil fertility [10, 11]. Compared to chemical fertilizers, organic manures like cattle and sheep barn manures contain essential plant nutrients (macro, micro and trace nutrients) and several vitamins which trigger plant growth and development [12-15]. In addition it had restorative impact on the soil's physical and biological properties [12, 16-18]. A previous study reported that farm yard manure applied at the rate of 16 t ha^{-1} remained instrumental in boosting growth and yield of soybean. It was inferred that soybean vegetative growth as indicated by leaf area, leaf number and chlorophyll content were increased owing to slow and steady decomposition which led to slow release of nutrients over a longer period of time [19, 20]. Likewise, organic manures like poultry shed wastes were applied after pit-composting at the rate of 2.5 t ha^{-1}, which resulted in higher growth and yield of soybean [21]. It was suggested that soybean vegetative growth was triggered under organic manures as those contained greater quantities of macro, micro and trace nutrients which assisted crop plants to attain higher chlorophyll contents and photosynthesis rate [22, 23]. In addition, it was also concluded that different organic manures from plants and animal origins performed differently and the impact of agro-climatic conditions was also pronounced on decomposition and rate of nutrients release from organic manures [24]. From above stated research findings, it becomes evident that site-specific testing of organic materials must be performed in order to establish the most superior organic manure under a specific set of soil and climatic drivers. Vermicompost prepared by using different types of worms has emerged as one of the most performing organic manure for cereal and legume crops [25]. Öztürk [26], stated that physiological parameters such as leaf area index and leaf chlorophyll content are vital indicators of crop growth rate and might be used as reliable traits to project crop growth development. Leaf area index; It is the leaf area per unit soil area and it is an important indicator used in determining the photosynthetic efficiency of plants together with the light intercept rate and light intercept efficiency [27, 28].

Keeping in view yield stagnation and the environmental hazards caused by chemical fertilizers, evaluation of organic sources for judicious utilization could potentially boost soybean growth and productivity. Up-till recently, serious research and knowledge gap exists pertaining to utilization of organic manures for boosting soybean physiological growth. Thus, we hypothesized that organic manures could potentially perform differently owing to varying decomposition rate and release of nutrients. The prime purpose of this research was to comparatively evaluate organic and chemical fertilizers and sort out the most superior source of manures for boosting physiological growth of soybean.

MATERIALS AND METHODS

Experimental Site and Soil. The field experiment was conducted at Research Area of Department of Field Crops, Dicle University during June to October 2019. The experimental site is situated at 37°53' N latitude and 40°16' E longitude at having an altitude of 668 m.The pre-sowing soil samples were taken from 0-30 cm depth for determination of physico-chemical properties of the soil. The soil contained 71.6% clay, 1.25% organic matter, 1.63 kg da^{-1} phosphorus, and pH 7.73. During experiment temperature fluctuated from 18.1 to 31.8 °C. The average temperature was around 25.3 °C while mean rainfall was 39.13 mm.

Experimental Treatments and Design. The seed of cultivated variety of Nova was used as planting material. The variety belongs to determinate group of plants. The experiment was comprised of different fertilizers sources and a Control treatment (no fertilizer). Treatments included chemical fertilizer (Cf) (80 kg N ha^{-1} and 80 kg $P_2 0_5$ ha^{-1}), manure from sheep barn (MSB) (5161 kg ha^{-1}), manure from cattle barn (MCB) (4878 kg ha^{-1}), liquid manure from cattle barn (LMCB) (27580 kg ha^{-1}) and vermicompost (VCm) (4000 kg ha^{-1}). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The plots were consisted from 4 rows with 6m of length, sowing was done with seed drill in 70x5 cm RxP spaces. Sprinkle irrigation was applied 8 times from emergence to the flowering period according to the needs of the crop plants.

Physiological traits. Leaf area index (cm^2/cm^2) and leaf growth rate (cm^2/m^2/day) were calculated according to formula developed by Radford [29] and Board [27], using the WINFOLIA leaf area program. For estimation of leaf area and crop growth rate, randomly 5 plants were harvested at different growth stages (R1= bloom initiation and R5= seed formation).

Leaf chlorophyll content (SPAD and CM-1000) values were determined at R1 and R5 growth stages of soybean by using SPAD-502 and CM-1000 chlorophyll meter. This method of measuring chlorophyll content has been regarded as non-destructive method for not damaging the plant leaves. For these measurements, 10 plants were randomly selected from each plot.

Statistical Analysis. Experimental data were subjected to analysis of variance with help of the computer package JMP 10. The mean values that were significant were further compared using the least significant difference test (LSD) at 5% and 1% significance levels.

RESULTS AND DISCUSSION

Leaf area index (LAI). The LAI is an important factor which affects the grain yield of soybean [1]. It gets effected by environmental conditions [30], plant growth period [26], sowing time [31] and [32], planting density [27, 33], potential of genotypes [26] and especially the plant nutrition management. The results revealed that LAI of soybean at R1 and R5 showed a highly significant difference ($P \leq 0.01$) among fertilizers applications (Table 1). The highest LAI was given by Cf application (5.50 R1 – 6.97 R2 cm^2 / cm^2), while the lowest corresponding value was obtained in control application (2.62 R1– 3.71 R2 cm^2 / cm^2, respectively). When comparing the R5 period to the R1 period, the highest leaf area index was recorded for LMCB (Figure 1 A). Our findings also revealed that LMCB application also positively affected LAI in the R2 development stage compared to other applications. It might be inferred that Cf provided nitrogen abundantly before the root nodules became fully functional and ultimately leaf area of soybean plants was increased. Interestingly, superior performance of LMCB might be attributed to slow and steady release of macro and micro nutrients which triggered vegetative growth of soybean plants compared to rest of the treatments. Liu [34] indicated that soybean varieties with different maturation groups and different yield potential reach the highest LAI value in R5 development stage. It was concluded that the difference in the LAI under different sources of manures was due to the variation in the number of leaves per plant. Similarly, Board [27] also reported that the highest LAI in the R5 period was obtained owing to more number of leaves and increase in leaf area due to plant nutrition management which led to maximize the LAI in soybean. Pedersen and Lauer [32] found that leaf area index decreased with the delay of planting Board and Harville [35] reported that reaching a LAI value of 3.5-4.0 at R1 was necessary to obtain economic yield as per varietal potential. It was inferred that leaf area index might be used as a reliable indicator for evaluating the photosynthetic functioning of crop plants and determining the biotic and abiotic crop damages. In addition, it was also reported that vigorous vegetative growth was key to achieve optimal seed yield of soybean and early flowering caused significant reduction in vegetative growth and LAI reduction which led to noticeable yield reduction.

Leaf Growth Rate. In terms of leaf growth rate (LGR), statistically significant difference was found between different manure management systems (Table 1). Figure 1B illustrated the impact of different manures management systems on LGR of soybean. As per our findings, the highest LGR was noted for LMCB (0.09 cm^2 / cm^2 / day), while the minimum corresponding value was given by MSB (0.02 cm^2 / m^2 / day) application (Table 1). It might be inferred that LMCB provided macro and micro nutrients abundantly slowly over a longer period of time which improved leaf area and ultimately LGR was triggered. These findings are in agreement with those of Iqbal [1]) and Yagoub [21] who reported that organic manures including cattle manure contained a variety of plant nutrients which assisted soybean plants to attain vigorous vegetative growth as indicated by greater leaf area and leaf growth rate. Likewise, Sadoh [36], Moreira [37] and Nagar [20] indicated that optimal plant nutrition management significantly affected leaf growth rate despite the fact that leaf number was found to be a genetically controlled trait having little or no effect of agronomic management practices. Öztürk and Söğüt [33] stated that while the leaf growth rate was 0.09 cm^2 / m^2 / day in late sowing time, the leaf growth rate were 0.13 cm^2 / cm^2 / day in normal sowing. Pedersen and Lauer [32] reported that there is a decrease in the leaf growth rate as the sowing time is delayed. Öztürk [26] stated that the sowing time and genotype have an effect on the leaf growth rate in soybean.

TABLE 1
The leaf area index (LAI), leaf growth rate (LGR), SPAD and CM-1000 values of soybean under different fertilizer sources.

Applications	LAI (R1) (cm^2/cm^2)	LAI (R5) (cm^2/cm^2)	LGR (cm^2/cm^2/day)	SPAD (R1) (cm^2/cm^2/day)	SPAD (R5) (cm^2/cm^2/day)	CM-1000 (R1) (cm^2/cm^2/day)	CM-1000 (R5) (cm^2/cm^2/day)
Control	2.62d	3.71e	0.04bcd	38.10a	36.80a	187c	160.66
Barn Manure (Sheep)	3.19b	3.92de	0.02d	31.06b	28.13b	200bc	166.65
Chemical Fertilizer	5.50a	6.97a	0.05bc	36.26ab	31.565b	293a	161
Barn Manure (Cattle)	3.28c	4.30d	0.03c	35.03ab	30.40b	213.67bc	153
Vermicompost	3.09c	4.70c	0.05b	32.96ab	29.41b	242.66b	179
Liquid Barn Manure (Cattle)	3.89b	6.57b	0.09a	31.03b	30b	232.64b	207
Variance	**	**	**	**	**	**	Ns
CV (%)	5.9	4.2	2.1	10	10.7	10.5	17.6

*Significance difference at $p \leq 0.05$. **Significance difference at $p \leq 0.01$, LSD: Least significant differences, CV: Coefficient of variation

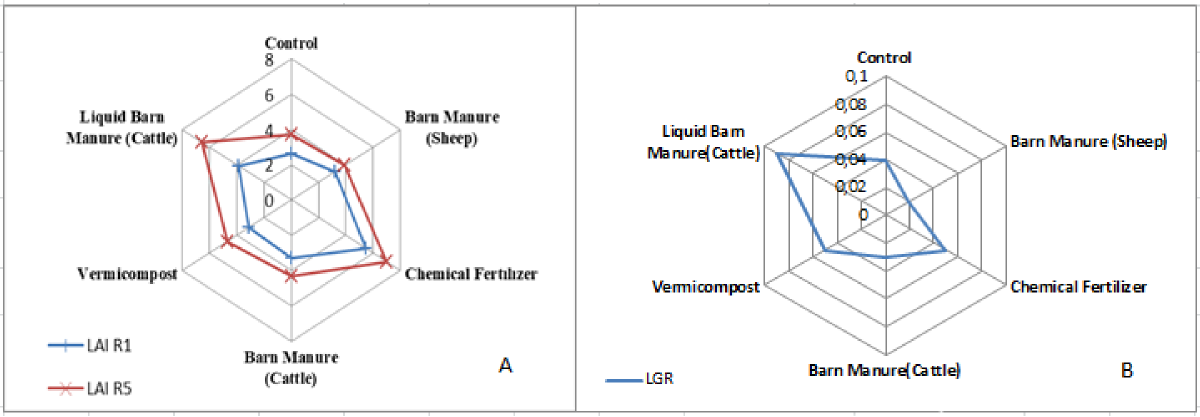

FIGURE 1
Visual graph of the effect of different fertilizer applications on leaf area index (A) and leaf growth rate (B)

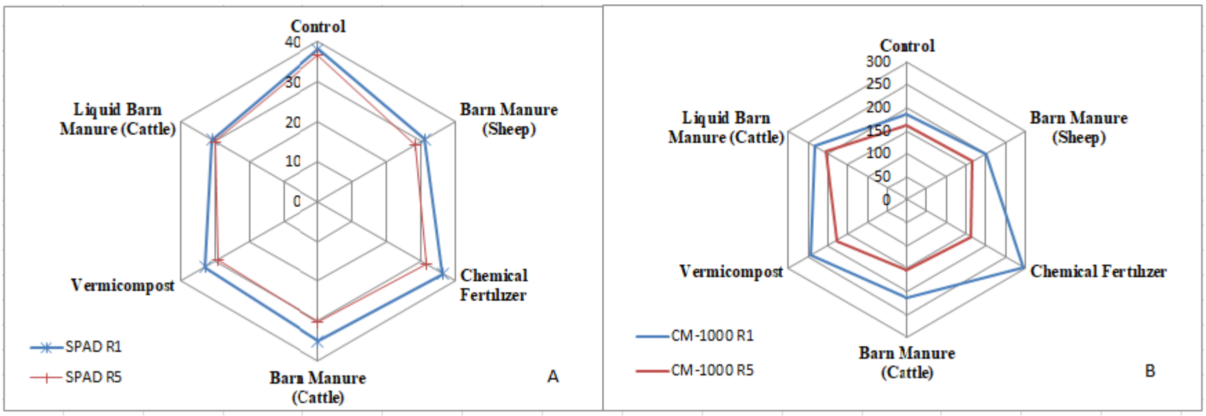

FIGURE 2
Radar graph of leaves chlorophyll content of (A) SPAD and (B) CM 1000 chlorophyll meters measured in soybean different periods

Chlorophyll content. The chlorophyll content values measured with SPAD and CM 1000 chlorophyll meters exhibited significant differences among various plant nutrition sources at R1 and R5 (Table 1). In our study, the average SPAD values of the applications in the R1 stage varied between 31.03-38.10. The maximum SPAD value was determined in the control (38.10) treatment, while the lowest value was noted for LMCB (31.03) and MSB (31.06) applications. It was observed that SPAD values varied between 28.13-36.80 in the R5 stage whereby the highest value was obtained for control (36.80) treatment. Other treatments were statistically at par to each other in terms of SPAD values of soybean when the plant growth stages were compared, it was seen that the highest decrease SPAD value in R5 compared to R1 was observed for MSB and Cf treatments (Figure 2 A).

Pertaining to CM-1000 chlorophyll measurements, significant difference among treatments was recorded at R1 growth stage of soybean, while non-significant differences were recorded at R5 growth stage at the R1 stage, CM-1000 values varied between 187-293, while the highest value was exhibited by Cf (293). The minimum corresponding value was recorded bycontrol (187) treatment At the R5 stage, the CM-1000 value varied between 153-207. It was seen that the highest decrease CM 1000 value in R5 compared to R1 was observed in Cf, MCB and Vcm treatments (Figure 2 B). The decrease in chlorophyll content during the R5 period was low in control treatment compared to LMCB and MSB treatments. Similar to our results, it has been previously chlorophyll content imparted positive effect on the yield of soybean as it assisted soybean plants to stay green for a longer period of time and continued photosynthesis at a greater rate [26]. Kizilgeci [38] stated that high chlorophyll content value in the plant is a desirable feature, and genotypes with high chlorophyll content under optimum environmental conditions will contribute to grain yield due to their greater photosynthesis capacity. Furthermore Fritschi and Ray [39] reported that SPAD measurements in soybean were not useful for estimating the N content of leaves because chlorophyll measurement is affected by genetic variation and environmental effects.

CONCLUSION

The results of our study were in line with the research hypothesis as chemical fertilizer remained superior in terms of physiological growth parameters such as leaf area index, leaf growth rate etc. Among organic manures, liquid manure from cattle barn performed superiorly as for as leaf area index at the R5 growth stage of soybean was concerned. At the same time, it was determined that leaf chlorophyll decrease in the R5 period was less in liquid manure from cattle barn compared to rest of treatments. Thus, it might be inferred that liquid manure from cattle barn could perform in an unmatched way especially pertaining to physiological growth parameters of soybean that could potentially multiply grain yield of soybean. Furthermore, it is also suggested to evaluate higher doses of organic manures such as liquid manure from cattle barn, vermicompost etc. in order to optimize their most performing doses for ensuring food security under changing climate.

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